Ranch management strategies for coping with impacts of watershed-scale externalities

Benjamin Turner*#; Dr. Roger Gates*#; Galen Hoogestraat$; Kelsey Ducheneaux*; Dr. Sandy Smart*
*South Dakota State University, Brookings SD; #West River Ag Center, Rapid City, SD; $United States Geological Survey (USGS), Rapid City, SD.

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1. Abstract

Land use change in Swan Creek watershed has contributed to increased stream discharge, leading to flooding on Rock Hills Ranch. We modeled single storm events to quantify the flood externality (i.e., "*unintended consequences*") and evaluated ranch strategies to cope with it. We suggested an **Easement strategy,** which provided an adequate financial return while creating a buffer to protect downstream properties in the watershed.

2. Introduction

Concern over loss of temperate grasslands is growing and the Northern Plains are acknowledged to be at great risk. While a national or regional perspective may remain abstract, we chose a specific case to consider the local impact of land use decisions. Rock Hills Ranch (RHR) borders Swan Creek in north central South Dakota (Figure 1). Rangeland upstream from RHR have been converted to row crop cultivation, driven, in part, by crop insurance subsidies. This has resulted in benefits to those land owners, but has led to unintended consequences. Flooding and ponding events have rendered 200 grassland acres of RHR useless (Fig. 2 and 3). We quantified these impacts using the Hydrologic Engineering Center's-Hydrologic Modeling System. Then, using a strategic management framework, the feasibility of two proposed strategies were evaluated.

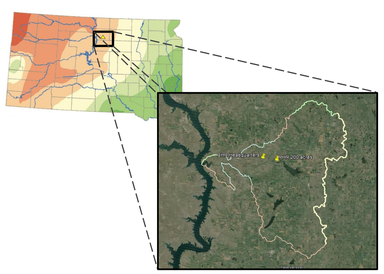


Figure 1. Map of South Dakota with marker for RHR. (Color lines delineate precipitation gradients). Enlarged areas shows the outline of the Swam Creek watershed, with markers for RHR headquarters and the location of ranch property most affected by flooding, driven by surrounding land use change.

Figures 2 and 3. Rock Hills Ranch site experiencing flooding, erosion, and sedimentation from increased stream discharge. RHR managers stand on a county road near ranch property along Swan Creek corridor.

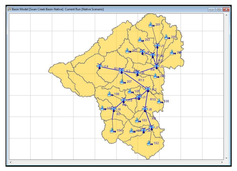
3. Watershed Impact Assessment

We estimated changes in land use in the watershed by aggregating the following crops: corn, sorghum, soybeans, sunflower, barley, and winter and spring wheat. From 2006 to 2012 there was **a change in over 21,000 acres (or 27.09%)** (Table 1) (Sources: NRCS Watershed Delineation Tool; USDA-NASS Cropland Data Layer).

Table 1. Swan Creek Watershed acres by county, percentage estimates for watershed by county, 2006 and 2012 crop acreage estimates, and level of crop acreage change. (Source: USDA Cropland Data Layer).

County	SC watershed in County (acres)	% of Watershed	2006 crop acres	2012 crop acres	Change
Walworth	188,226	53.3%	62,112	71,112	9,000
Potter	146,919	38.0%	64,963	76,761	11,798
Edmunds	33,698	8.7%	9,402	10,273	872
Total	368,842	100%	136,476	158,146	**21,670**

Estimated changes were then used to parameterize the HEC-HMS watershed simulator (Figure 4).



HEC-HMS model inputs:
Major soil hydrologic group: B
Weighted ave. SCS Curve numbers:
- 67.66 (2006 scenario)
- 68.72 (2012 scenario)

Initial abstraction values:
- 0.1629 (2006)
- 0.1571 (2012)

Impervious cover (%): 0.5

Figure 4. HEC-HMS model and input values. Outputs were calculated based on: Loss (SCS curve number), Transform (Clark Unit Hydrograph), Baseflow (Recession), and Routing (Lag) techniques.

Output hydrographs (Figure 5) demonstrate that **discharge of a single storm event has increased over 4.5% (or 110,000 gallons per second at peak-flow).**

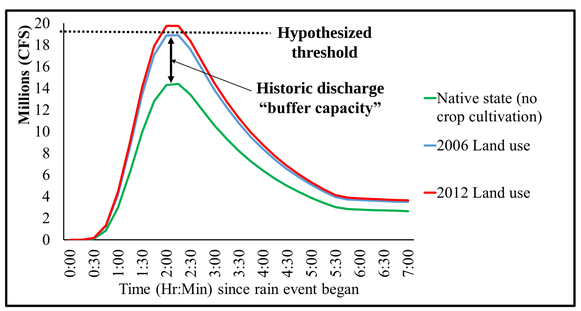


Figure 5. HEC-HMS hydrograph outputs. Simulations were run using a 1.5'', 2 hour rainfall event.

Shifting the Burden of Conservation: Experience (Figures 2 and 3) and research (Figure 5) suggested SC's discharge volume (accelerated by land use change) has crossed an historic threshold, something RHR cannot effectively manage alone. Identifying strategies to cope with this problem was the next logical step.

4. Strategy Development

Prior to developing potential coping strategies, we conducted a **SWOT** Analysis (Table 2) of RHR's current position to guide our evaluation criteria.

Table 2. SWOT Analysis of RHR to facilitate strategy development and evaluation criteria.

Strengths	Weaknesses
•Multi-generational invested	•Rainfall amount & distribution
•Highly flexible operation	•Available non-family labor
•Water and fencing improvements	•Distance to national policy circles
•Hunting enterprise and on-site lodge established	•Proximity to Swan Creek confluences
•Financial position	
Opportunities	**Threats**
•Growth of out-of-state hunting / recreation interest	•Reductions in conservation program funding
•Easement structures from private organizations	•Increased land use conversion
•Grass lease availability	•"New normal" of flooded Swan Creek properties
•Strong cattle market continues	•"Bear" cattle market swing

Strategies were identified based on divergent tracks: continued land ownership vs. selling land. Selling land simply **'shifts the burden'** onto a new landowner without mitigating the risks to downstream ranch property. Since land ownership was a priority, only the "***Keep Land"*** strategies are presented below (Table 3).

Table 3. Potential strategies and their resources, risks, and effectiveness for mitigation. [1]Multiple easements exist depending on conservation and management goals. [2]Managing for habitat may be included in an easement or financed privately. We assumed this would be privately driven. [3]The Leasing Grass strategy is flexible enough that it can be coupled with any of the ***Keep Land*** options, not just a standalone strategy. We included these options in our analysis that follows.

Strategies	Potential Ranch Benefit	Ranch Investment Level	Resources and Costs	Risks Associated	Effectiveness for Problem Mitigation
Keep land:					
Lobbying for conservation	High	Medium	Travel and communications	Time away from ranch, day-to-day knowledge reduced	Slight-to-moderate (depending on national attitudes and local adoption)
Tile drainage	Medium	High	Tile supplies, equipment, and installation costs	Causing further damage to neighbors	Slight (depending on severity of rain events)
Strategic grazing/haying	Low	Low	Electric fencing, additional labor, investment in feed	Reduced AUD's from plant community change, cattle health concerns	None-to-slight (mismanaged grazing might accelerate erosion)
Put into easement[1]	Medium	Medium	Legal set-up, annual maintenance costs	Reduced flexibility on owned land	Moderate (non-use, an expansive filter strip)
Manage for habitat[2]	High	Low	Hunting supplies, installation, habitat construction, labor for guides	Additional traffic on ranch	Moderate (creates filter strip while fostering diversity)
Leasing Grass elsewhere[3]	Medium	Low	Funds for grazing lease	Herd and pasture health, lease productivity	Moderate (non-use, creates expansive filter strip)

For our analysis we selected strategies with **moderate mitigation effects**: 1) Put into easement, or 2) Habitat management. Both strategies ***convert a threat into an opportunity*** and fit RHR's long-term goals (continued ownership, adequate flexibility, no ranch-carrying capacity impacts) while ***providing relief as a buffer area*** for the rest of the watershed.

5. Strategic Analysis

After obtaining costs and revenues for each strategy, Net Present Values (NPV) and Modified Internal Rates of Return (MIRR) were calculated over a 10-year planning horizon (Table 4).

Table 4. NPV and MIRR estimates of moderate strategies chosen for analysis. [1]NPV- present value of all cash inflows and outflows using a 2.5% discount rate. [2]MIRR- internal rate of return assuming positive cash flows are reinvested in firm and earn 1% thereafter. [3]Easement value assumes that 30% of the property value is relinquished and some residual forage value remains on property; tax implications were not considered in this analysis. [4]Same easement description as above but with emphasis and investment in habitat development and hunting enterprise. [5]The major difference in this scenario is that it lacks the initial cash inflow created with an easement, all other cash flows are similar.

Strategy	NPV[1]	MIRR[2]
Easement with leased grass[3]	($3.72)	21.84%
Easement (for habitat) with leased grass[4]	($25.04)	13.24%
Habitat (with leased grass)[5]	($24.14)	0.32%

Strategy selection: The generic Easement strategy provided an economic benefit that allows RHR to recoup losses from years when flooded land was inaccessible while also salvaging some forage potential for more favorable years. Upfront investments and annual costs were lower without the emphasis on habitat development and hunting potential. We recommend identifying easement partners as the next logical step for RHR.

6. Conclusions

Crop insurance subsidies influence rangeland to crop production conversion decisions. Reduced financial risk benefits farmers in semi-arid environments. Analogous benefits do not exist for grassland-based livestock production. The RHR case demonstrates that well intentioned land use decisions are not externality-free. Watershed discharge volumes may become unmanageable for stream corridor properties. Our analysis (Table 1, Figure 5) suggests RHR has no opportunity to limit consequences with traditional management: ***it can only react***. Among management alternatives, we found an **Easement strategy**, while leasing grass elsewhere, would be most appropriate. This strategy provides adequate financial return, **converts externality impacts into an opportunity**, maintains forage management flexibility, and creates an effective vegetative buffer for downstream properties.

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